OBSERVATIONS ON THE PULSATING ORGANS IN THE LEGS OF CERTAIN HEMIPTERA.[1]

BY WM. A. LOCY.

CONFLICTING opinions have been held regarding the pulsating organs that have, from time to time, been observed in the legs of certain Hemiptera.

They were first drawn and described by Behn, in 1835. These observations were at once called into question by Léon Dufour, who at that time was the acknowledged autocrat of the anatomy of the Hemiptera.

Dufour considered that these movements were due to contractions of the ordinary muscles of the legs and denied the existence of the blood currents observed by Behn. The scientific value of Dufour's opinion on this point loses its force on account of his well known hostility to the theory of circulation of the blood in the Insecta.

In the summer of 1883, while working on the circulation of blood in the Hemiptera, these organs came under my notice, and the following is a simple record of observations made to determine:

(1) Whether these organs are distinct from the muscular system of the legs, and

(2) Whether they influence circulation?

To both of these questions the evidence is for an affirmative answer. During the progress of the work their automaticity was also observed and well established.

Methods.—Different genera of the aquatic Hemiptera were fastened upon a microscope slide, their legs spread out in glycerine and covered with a cover-glass. The legs thus prepared were studied with both low and high powers of the microscope. Specimens for examination were chosen with reference to the transparency of their legs, as it is upon this point that success of observation depends. Both larval and adult forms of the genera studied were used, but the best results were uniformly obtained with the larval forms, on account of the greater transparency of their legs.

In some cases special methods were necessary to render the legs transparent enough for observation. For this purpose the

[1] Work from the Biological Laboratory of Mt. Morris College, Mt. Morris, Illinois.

integument of the legs was scraped very thin. The organs can be demonstrated in this manner, even in the thick legs of the adult Belostomæ.

The organs are most easily seen in the legs of Notonecta and Corixa, but are not so large and pronounced as in the legs of the Nepidæ. In the more transparent individuals not only are the organs readily seen, but the circulation of the blood can be watched with a power high enough to bring out the corpuscles.

The pulsating organs were noted in the following genera: Corixa, Notonecta, Gerris, Belostoma, Perthostoma and Ranatra; particular attention having been given to the organs in Belostoma, Perthostoma and Ranatra.

Description.—These organs are found in the three pairs of legs of all the genera mentioned above. They are generally in the tibia of the leg, just below its articulation with the femur. In the raptorial legs of Ranatra, however, the organs are in the clasp-joint or tarsus just below its articulation with the tibia.

Examined with a power of seventy-five diameters, they appear as little whip-like organs pulsating rapidly. In the Nepidæ they lie outside the median line of the leg, towards the front side, being slightly convex towards the outside. This curved body which forms the bulk of the pulsatile organ, is attached at both ends and from its sides several attachments extend upwards and backwards to the integument of the leg (see Fig. 4).

The shape in Corixa and Notonecta is quite different; it is somewhat hand-shaped in Notonecta, and in Corixa the shape of an inverted letter L, with its lower portion prolonged. This hangs down into the leg-cavity beyond the median line.

Crossing these organs obliquely, in the Nepidæ, lie the muscular fibers of the legs. The bands of muscle appear either straight or wavy, according as the legs are bent or extended, and remain perfectly quiet while the organs are beating. A careful study of the muscular system of the legs was first made, to avoid confusing it with the organs in question. With a power of 150 diameters it can be made out very satisfactorily that the pulsatile organ is a thing separate from the muscular fibers of the leg, and does not involve them in its motion. This is best seen by focusing back and forth. When we have the muscles clearly in focus, the movements of the pulsating organ can still be seen lying a little out of focus. In some of the thick-legged specimens, where a dis-

FIG. 1.

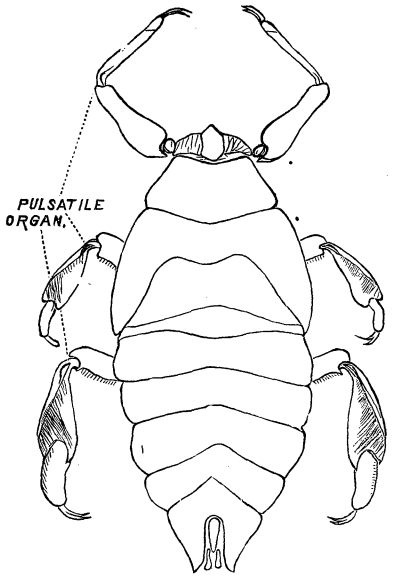
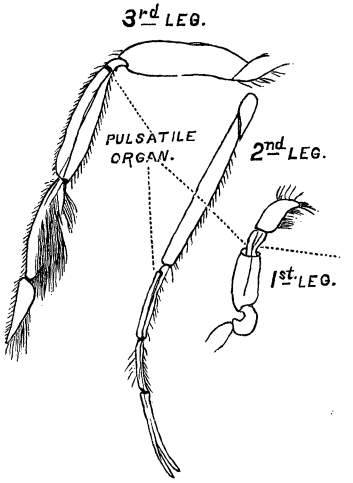


FIG. 2.



PULSATILE ORGAN.

FIG. 3.

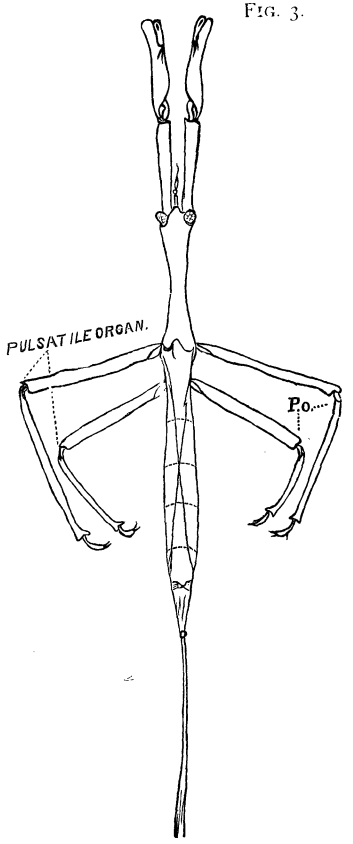
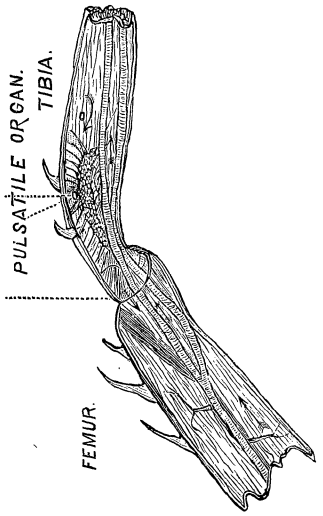


FIG. 4.



PULSATING ORGANS IN HEMIPTERA.

tinct focus could not be obtained, the pulsations seemed to involve the muscular fibers, but scraping the integument thin, so as to admit more light, showed that this appearance was due to the general indistinctness.

The pulsating organs are also unaffected by the movements of the muscles of the legs. On several occasions, when the legs were moving back and forth and the muscles all in action, the pulsatile organ has been observed beating naturally, wholly unaffected by their movements.

Influence upon circulation, etc.—In studying the influence of these organs on circulation, they were observed with powers of the microscope ranging from 187 to 438 diameters. Either of these powers is sufficient to bring out the blood corpuscles.

In the legs of the insects in question there are two blood currents, an outgoing current and a returning current. The outgoing current passes along the inside of the leg, below the pulsating organ, and the returning current passes to the outside of the leg, above the pulsating organ. As the blood currents flow near the pulsatile organ they move faster, and around the organ itself there is a whirlpool of motion. Here the corpuscles can be seen rolling over and over one another, and striking against the pulsatile organ, by which blow they are driven whirling along their course.

The beating of these organs in the Nepidæ is such as to aid circulation in both directions; and of their influence over it there is abundant proof. The motion of the pulsating organ is difficult to analyze and describe. In an organ beating slowly the motion is seen to originate in the posterior end, spread wave-like forwards to about the middle of the organ; the anterior end simply rising and falling. It may be likened to the motion of a whip-lash, resting on the ground, when the stock is given a quick upward stroke. It is to be understood that the "anterior end" means the end towards the head of the insect, and the "posterior end" the one opposite, towards the extremity of the leg. The attachments have no movement of their own, but are set in motion by the organ. This motion in the rapidly-beating organ resolves itself into an upward beat of the posterior end almost simultaneous with a downward stroke of the anterior end. Such an arrangement would aid the circulation of the blood. As the posterior end beats upward, it would make room for the outgoing cur-

rent and, at the same time, force along the returning current. The outgoing current would almost instantaneously receive an impetus from the downward stroke of the anterior end.

The influence of the pulsating organ on circulation is shown, not alone by the energetic movements of the blood currents in its vicinity, but also when the motion ceases in it the blood currents stop. I have never observed circulation in the legs while these organs were quiet; nor have I failed to detect it when they were in motion, except in a few specimens too opaque to show the blood corpuscles. The stopping and commencing of the blood currents, induced by the pulsating organ, have been repeatedly observed. As soon as the pulsatile organ stops, the blood currents immediately cease in that particular leg, and the first motion of the blood is a slow retrograde movement which is particularly noticeable around the pulsatile organ, since here the corpuscles are thickest. A slow oscillation sometimes takes place, similar to the movements in a frog's capillaries, when circulation is suspended in the web. With the first stroke of the pulsatile organ, circulation is resumed, and continues until the pulsatile organ again stops.

The influence of each pulsatile organ is confined, as near as I can make out, to a single leg, as circulation was noticed in progress in the body and in other legs during its cessation in one leg.

In their intermittent action the periods of rest are comparatively short and independent of each other. Their periods of rest sometimes correspond, however, and the pulsatile organs of one side of the body may all be in a quiescent state at the same time.

My observations on the rate of beating of these organs are fragmentary, but, as far as they extend, they show that while considerable irregularity exists in this regard, the rate of the pulsatile organ is always faster than the rate of the heart in the same insect. For instance, in Belostoma where the heart beats were from thirty-four to forty-five per minute, the pulsating organs were beating from 127 to 150 times per minute. In Notonecta, where the heart was regular at seventy per minute, the pulsatile organs were beating 170 to 216 times per minute. In Ranatra the pulsations were several times counted as high as 175 per minute. These insects were too opaque to admit of counting the heart bearts.

Observations on Amputated Legs.—A strong proof that the pulsatile organs are separate from the general muscular system of the legs, is found in their automaticity. About twenty-five observations have now been made with the amputated legs of Ranatra and Perthostoma to study this phenomenon. When an amputated leg is placed under observation, the pulsatile organ is seen in motion similar to its action during life. It has already been noted that the pulsations are somewhat intermittent in life, and this characteristic is usually aggravated after amputation, so that the stops are more frequent and longer continued than before amputation.

These observations are not complete enough to establish the limit of automaticity. In one instance, however, I traced the beating of the pulsatile organ in the amputated leg of an adult Ranatra through a period of twenty-six hours and twenty minutes. The duration of beating in an amputated leg is probably greatly affected by circumstances, and it may, therefore, continue longer than in the case just cited, or stop sooner, according to circumstances.

The pulsating organ continues its beating even when sliced portions of the legs are used instead of whole legs. It was cut in two, and the posterior part, which was attached to a fragment of the leg, still continued to beat.

One set of observations on an amputated leg, that fairly represents the others, is given below in detail:

On Oct. 3, 1883, the front leg of an adult Ranatra was put under observation at 1.45 P. M. The pulsations were regular from 135 to 140 per minute. After watching for ten minutes the leg was cut off close to the body with a sharp razor. During this operation the eye was kept upon the pulsating organ through the microscope. The only perceptible effect was a slight increase in the rate of beating, which was now found to be 146 per minute. For the next ten minutes the amputated leg was under constant observation. It continued beating during this time, towards the close at a slightly diminished rate, say 135 pulsations per minute. At 2.05 P. M. I was called away.

The next observation was made after an absence of one hour and thirty minutes, at 3.35 P. M.; the organ was then beating regularly at 115 pulsations per minute. No change was observed up to 3.45 P. M., at which time the specimen was laid aside.

From 4.20 P. M. to 9 P. M. seventeen distinct observations were made, varying from one to seven minutes each. The actual time spent at the microscope during this period was forty-five minutes. For four minutes of this time the organ had been quiet.

After 5.20 P. M. it gradually fell from 103 pulsations per minute to 43 per minute, at 8.30 P. M.; from this time it began an increase that had reached 116 at 8.55 P. M.

From 9 P. M. to 10.30 P. M. forty-seven minutes were spent at the microscope, divided among thirty-six observations, the pulsations during this time gradually falling from 120 per minute to 50 beats per minute.

At 10.50 P. M. I retired, leaving the organ beating at 50 per minute.

The following morning, Oct. 4, 1883, at 6.50 A. M., the organ was not beating. At 9.50 A. M. regular observations were again commenced, and up to 1.27 P. M. twenty-nine distinct observations had been made, occupying thirty-eight minutes of actual study. The rate varied from 67 to 24 beats per minute, being the greater part of the time at 55 per minute.

No sudden transition of rate was observed in this specimen; the fall from 67 to 24 taking place gradually, the lowest limit having been reached, the rate would again increase to the high limit. Hot air blasts were several times blown over the microscopic slide after the organ had been beating twenty-one hours. The usual effect was to increase the rate and strength of beating for a short time.

The other observations do not differ in any essential particular from the one given above. They were all made in less time, however; the longer ones being several hours shorter than the one detailed.

The automaticity has also been noted in the amputated legs of Notonecta and Corixa.

The work on the histology of these organs has yielded, as yet, no definite results.

To conclude, then, in my estimation the three points mentioned at the outset have been established, viz:

(1) The pulsatile organs are separate from the muscular system of the legs.

(2) They influence circulation.

(3) They are automatic.

EXPLANATION OF PLATE I.

FIG. 1.—Belostoma larva, to show the location of the pulsatile organs. In all three pairs of legs they are in the tibia, just below the articulation with the femur.

FIG. 2.—Location of the pulsatile organ in the legs of Corixa. In this genus the chitinous cord, to which the pulsatile organ seems attached, is set in motion by its beating. The motion of this cord sometimes extends through three joints.

FIG. 3.—Ranatra, adult, to show the exceptional position of the pulsatile organ in the fore legs.

FIG. 4.—The pulsatile organ as seen in the tibia of an adult Ranatra. At the posterior end are seen the attachments extending upwards and backwards to the integument of the legs. Crossing the anterior end and middle portion are the oblique muscular fibers of the legs. The tracheæ are plainly shown. The arrows indicate the direction of the blood currents.

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ON THE CHARACTER AND FUNCTION OF THE EPIGLOTTIS IN THE BULL-SNAKE (PITYOPHIS).[1]

BY CHARLES A. WHITE, M.D.

AMONG the more commonly known serpents of the United States there is a group of species which naturalists range under the generic name of Pityophis, and which are distributed from the Atlantic to the Pacific coast. To all these species the popular name of bull-snake is applied, and the more common eastern variety is also often popularly called the pine-snake. They are great, good-natured fellows, always getting out of man's way when they can, but occasionally, if they are pressed, they will throw themselves into a somewhat threatening attitude and emit a peculiar hiss. The old naturalist, William Bartram, spoke of it as a "terrible hiss, resembling distant thunder," but even with the popular dislike to serpents, I think few persons would regard the hiss of the bull-snake as at all terrible or thunderous.

Baird and Girard, Cope, and Yarrow, have all published lists of species of Pityophis. Baird and Girard enumerated seven species; Cope, five species, dividing one of them into three varieties; and Yarrow four species, dividing one of them in two varieties.

All these forms have similar habits, and all, at times, produce a similar hoarse, hissing sound. It is well known that a hissing sound is produced by other serpents as well as other animals; but the hiss of the bull-snake has a peculiar hoarseness which is sometimes so loud that, with the help of the imagination, it appears to have

[1] Read before the Biological Society of Washington, October, 1883.